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Using VFT and Optimization to Create the Acquisition Portfolio for the Marines Infantry Optics

MORSS June 2008

Background

▸ Since 2003 the USMC Program Manager for Optics has invested considerable resources to meet Urgent Universal Needs Statements from the Operating Forces for enhanced optics. Since the needs identified were urgent, there was not time to fully understand how these different systems would work together.

▸ **Bottom Line:** How useful is our current optics portfolio, and what are some cost effective solutions to improve it?

▸ **Study Objectives:**

  – Identify capability gaps and technological shortcomings of current and near-term optics systems, and

  – Provide recommendations and courses of action on a suite of systems to resolve those capability gaps and technological shortcomings.

Study Characterization

▶ There are four "Buckets" of capability as defined by ICDs that are highly **interrelated.**

– Hand Held, Helmet Mounted, Weapon Mounted, Crew Served

▶ Capability value is **dependent** on the Five Scenarios and who is using the system.

▶ Value of a system is dependent on what others in the unit have.

▶ Data:

– Initial metrics had been determined but little data had been gathered against the alternatives.

– Some testing had been done

– A lot of system level data gaps

– Like many situations where there was rapid fielding to meet urgent needs, there was no comprehensive knowledge of who had what equipment and what equipment was being used.

Accomplishments

▶ Two level analysis

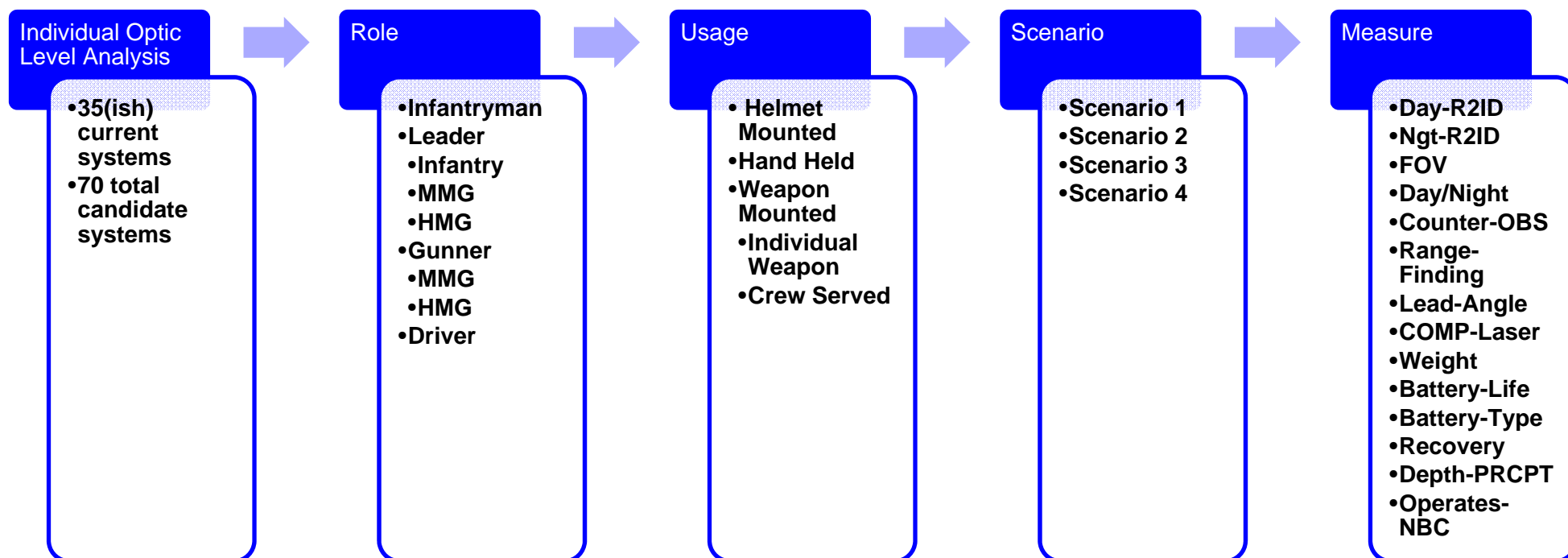– System Level Analysis: The analysis helped determine the "best" system within each role and usage, such as Infantryman Head-Mounted.

– Portfolio Level Analysis: The analysis gave insight into portfolio level trade to ensure that the optics systems were true treated as a family of systems.

▶ Unique use of linear programming to ensure capability gaps were fulfilled and addressing competing objectives.

Initial Fundamental Objectives Hierarchy

Fundamental Objective

- **Hand-held**
  - Prevent Enemy Passage
  - Attack a Fortified Position
  - Conduct Urban Patrol
- **Head-mounted**
  - Prevent Enemy Passage
  - Attack a Fortified Position
  - Conduct Urban Patrol
- **Weapon-mounted**
  - Prevent Enemy Passage
  - Attack a Fortified Position
  - Conduct Urban Patrol
- **Crew-served**
  - Provide Convoy Security (Gunner)
  - Provide Convoy Security (Driver)
- **Scout/sniper**
  - Conduct Route Recon
  - Conduct Surveillance
  - Provide Over Watch

Functional Decompositions of Scenarios
Task to Capability to Metric

Performance
- Range
- Field of View

Secondary Performance
- Blooming Recovery

Burden
- Weight

Function/ Environment
- Laser Illume
- Day to Night
- Obscured Target

New Structure for Individual Optic Evaluation

Individual Optic Level Analysis

- 35(ish) current systems
- 70 total candidate systems

➡️

Role

- Infantryman
- Leader
  - Infantry
  - MMG
  - HMG
- Gunner
  - MMG
  - HMG
- Driver

➡️

Usage

- Helmet Mounted
- Hand Held
- Weapon Mounted
  - Individual Weapon
  - Crew Served

➡️

Scenario

- Scenario 1
- Scenario 2
- Scenario 3
- Scenario 4

➡️

Measure

- Day-R2ID
- Ngt-R2ID
- FOV
- Day/Night
- Counter-OBS
- Range-Finding
- Lead-Angle
- COMP-Laser
- Weight
- Battery-Life
- Battery-Type
- Recovery
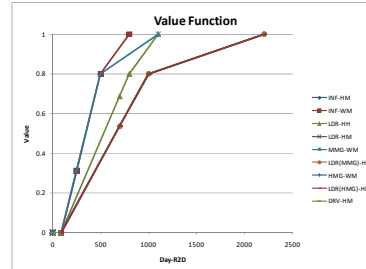- Depth-PRCPT
- Operates-NBC

▸ Twenty-three R-U-S level paths

– Example: Infantry Leader- Helmet Mounted - Scenario 1

Value Focused Thinking approach was taken for initial Individual Optic analysis

Swing for each measure was define (refined several times)

Value Functions (refined several times)

Swing Weight (One for each R-U-S)

Alternative Development and System Applicability
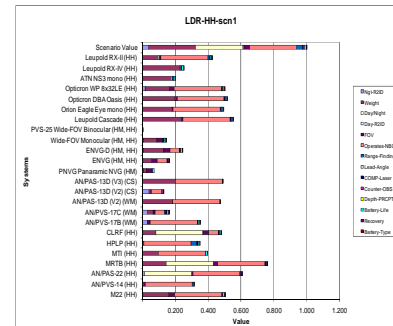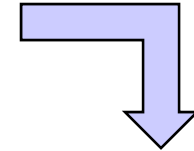
Evaluated the Alternatives (for each R-U-S)

- ▸ Example of Value Based Alternatives added
  - – Integrated laser into optics: Already bore sited, one less optic, total is lighter weight
  - – Mononcular with LRF: Lose depth percentage but gain active range finding, decreased weight and cost.
- ▸ Good at evaluating individual systems
- ▸ But from a Pf level, misses relationship between Roles and also between alternatives

New Cost Benefit (Aggregated to R-U Level)
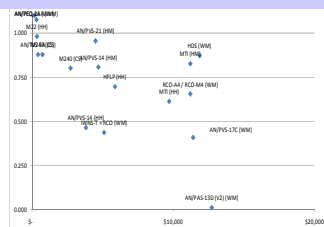
Identified New Value Based Alternatives

Evaluated Cost Benefit (Aggregated to R-U Level)
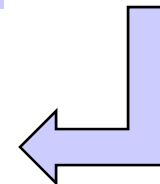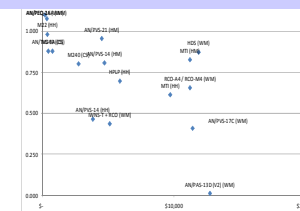
Evaluating the Family of Individual Optics study

▸ We had the Individual Optics (system level) analysis pretty good

▸ Now we have to deal with the family. Some system "types" were not selected because of cost but they provide capability.

▸ We need to define Family (portfolio) level capability.
  – This is more difficult because they hadn't been defined before.

"Best" Day Sites

"Best" Thermal Site

▶ Infantry Leader and Infantry can leverage capability. Leader has to have the same or greater capability --- Sometimes

– Taking into account three factors should allow for MECE evaluation

■ Day

■ Night

■ Obscurants
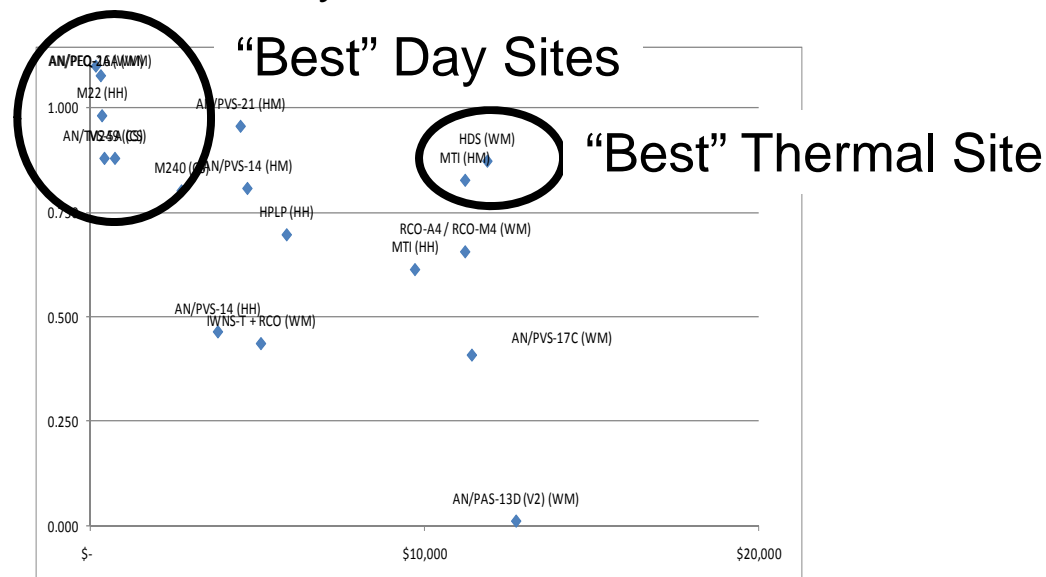
Pf Level Issue 1: Relationship between Roles

Examples of Leveraging and Satisfying

Ldr: Can you ID that bad guy?
Inf: Yes!
Ldr: Okay, shoot him.
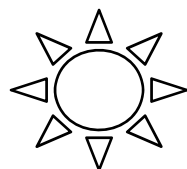
Day Time/ XX Meters
(No need to leverage)

Ldr: Can you ID that bad guy?
Inf: No.
Ldr: I can, can you see my laser?
Inf: Yes!
Ldr: Okay, shoot him.

Night Time/ XX Meters
(Opportunity to leverage)

Ldr: Can you ID that bad guy?
Inf: No.
Ldr: I can, can you see my laser?
Inf: No.
Ldr: Okay, I'll shoot him.

Obscurants / XX Meters
Leverage is more difficult

Pf Level Issue 2: Relationship between Usage

▶ Infantryman can use one (or more) device to accomplish a mission.

- Helmet Mounted 1x I^2 optic to maneuver at night (base capability)
  - They use a head mounted eyeball during the day
- Plus an 4x I^2 clip on to increase range and a 4x IR handheld to see through obscurants.
  - Downside: Greater range potential but more systems to worry about, more total weight
- A 4x helmet mounted fused I^2 plus IR optic to increase range and see through obscurants.
  - Downside: Fewer systems and less total weight BUT lower performance and more weight on your head

All ounces are not equal

▶ Leaders need to sense and detect, as well as Identify.

▶ Infantrymen need to sense to maneuver but identify to engage

One Pf Level Solution Identify a Domain

▸ Establish a Domain level required capability

– Domains determined by how Marines fight.

Capability for each Role and Usage:
Completing a **Task** in a **Condition** to a **Standard**.

The standard were defined as the value measures within the context of the Marines Role and how the optics would be used.

Task	Condition	Infantry		Leader (ft, sqd, plt)		
		HM	**WM**	**HH**	**HM**	**WM**
Sense	Day			Required		
	Night	Required		Optional	Required	
	Obs	Leverage		Required (HH or HM)		
Engage	Day		Required	Optional		Required
	Night	Required (HM or WM)		Required (HH, HM or WM)		
	Obs		Leverage	Required (HH, HM or WM)		

Whether a capability was required (leverage or optional) was determined by the study team and verified by an operator panel

Domains allow for identifying building blocks within the Pf

▸ This construct allows for identification of capability gaps.

2007 Pf

Infantry			
HM	System(s)	**WM**	System(s)
Sense Day			
Night Required	AN/PVS-14 (HM)		
Obs Leverage			
Engage Day		Required	RCO-A4 / RCO-M4 (WM)
Night Req'd w/in Role	AN/PVS-14 (HM)	Req'd w/in Role	AN/PEQ-2A (WM)
Obs		Leverage	

LDR (Section)					
HH		**HM**		**WM**	
Sense Day Required	M22 (HH)				
Night Optional		Required	AN/PVS-14 (HM)		
Obs Req'd w/in Role					
Engage Day Optional				Required	RCO-A4 / RCO-M4 (WM)
Night Req'd w/in Role		Req'd w/in Role	AN/PVS-14 (HM)	Req'd w/in Role	AN/PEQ-2A (WM)
Obs Req'd w/in Role					

2010 Pf

Inf			
HM		**WM**	
Sense Day			
Night Required	AN/PVS-14 (HM)		
Obs Leverage			
Engage Day		Required	RCO-A4 / RCO-M4 (WM)
Night Req'd w/in Role	AN/PVS-14 (HM)	Req'd w/in Role	AN/PEQ-16A (WM)
Obs		Leverage	

LDR (Section)					
HH		**HM**		**WM**	
Sense Day Required	M22 (HH)				
Night Optional		Required	AN/PVS-14 (HM)		
Obs Req'd w/in Role	MRTB (HH)	Req'd w/in Role			
Engage Day Optional (range finding)				Required	RCO-A4 / RCO-M4 (WM)
Night Req'd w/in Role	Leverage WM	Req'd w/in Role	Leverage WM	Req'd w/in Role	IWNS-I2 (WM)
Obs Req'd w/in Role	Leverage WM	Req'd w/in Role	Leverage WM	Req'd w/in Role	IWNS-T (WM)

Building blocks can be put together to identify Pf metrics

▶ Unit of analysis is the Infantry Company with Heavy Machine Gun platoon.

– It addresses the needs of the most demanding users and gives a basis for identifying Pf level metrics

  ▪ Total Pf Value, Total Weight, Total Number of Systems (Human Factors), Total Number of Unique systems (sustainability measure)

Putting the Building blocks together will get 90% there

Some gaps like M203 site and M249 site hard coded, since the solution is already known.

So how do you solve the problem?

4   Pf level metrics
70   Alternatives
23   Scenarios
4   Domains
2   Functions
3   Environments

	Calculated		Constraint	
C1	1.00	=	1	Infantry must have a helmet-mounted sensor for night sensing capability
C2	1.00	=	1	Infantry must have a weapon-mounted sensor for day engaging capability
C3	1.00	=	1	Leader must have a hand held day sensing capability
C4	1.00	=	1	Leader must have a helmet-mounted night sensing capability
C5	1.00	=	1	Leader must be able to sense through obscurants (HH or HM)
C6	1.00	=	1	Leader must have a weapon-mounted sensor for day engaging capability
C7	1.00	=	1	Infantry must be able to leverage night/obscurant long range fires
C8	1.00	=	1	There can only be one Helmet mounted system per Marine
C9	1.00	=	1	Leader must have weapons mounted engagement capability for night
C10	1.00	=	1	Leader must have weapons mounted engagement capability for obscurants
C11	1.00	=	1	MMG must have a weapon-mounted engagement for day/night/obs
C12	1.00	=	1	MMG Leader must have a hand held day sensing capability
C13			1	MMG Leader must have ... to sense through obscura... MMG leverage
C14				...must ha... ...systems f...

System Name	D	N	O	Isr	INF-HM	INF-WM	LDR-HH	LDR-HM	MMG-WM	LDR(MMG)-HH	HMG-WM	LDR(HMG)-HH	DRV-HM
					Number of units required for Marine Rifle Co.								
					121	121	62	62	6	6	6	6	3
Alternative System 1		X			0			0					0
Alternative System 2		X			0			0					0
Alternative System 3			X		0			0					0
Alternative System 4		X			0			0					0
Alternative System 5		X	X		0			0					0
Alternative System 6		X	X		1			0					0
Alternative System 7		X	X		0			0					0
Alternative System 8		X			0			1					0
Alternative System 9	X						0			0		0	
Alternative System 10	X						0			0		0	
Alternative System 11	X						1			0		0	
Alternative System 12	X						0			0		0	
Alternative System 13	X						0			0		0	
Alternative System 14		X					1			0		0	
Alternative System 15	X						0			0		0	
Alternative System 16	X						0			1		0	
Alternative System 17	X						0	0		0	0	0	
Alternative System 18	X						0			0	0	0	
Alternative System 19	X						0			0		1	
Alternative System 20		X					0	0		0		1	
		X					0					0	
	X												

▸ Linear Program
  – 70 Alternative
  – 119 Decision Variables
  – 27 Constraints
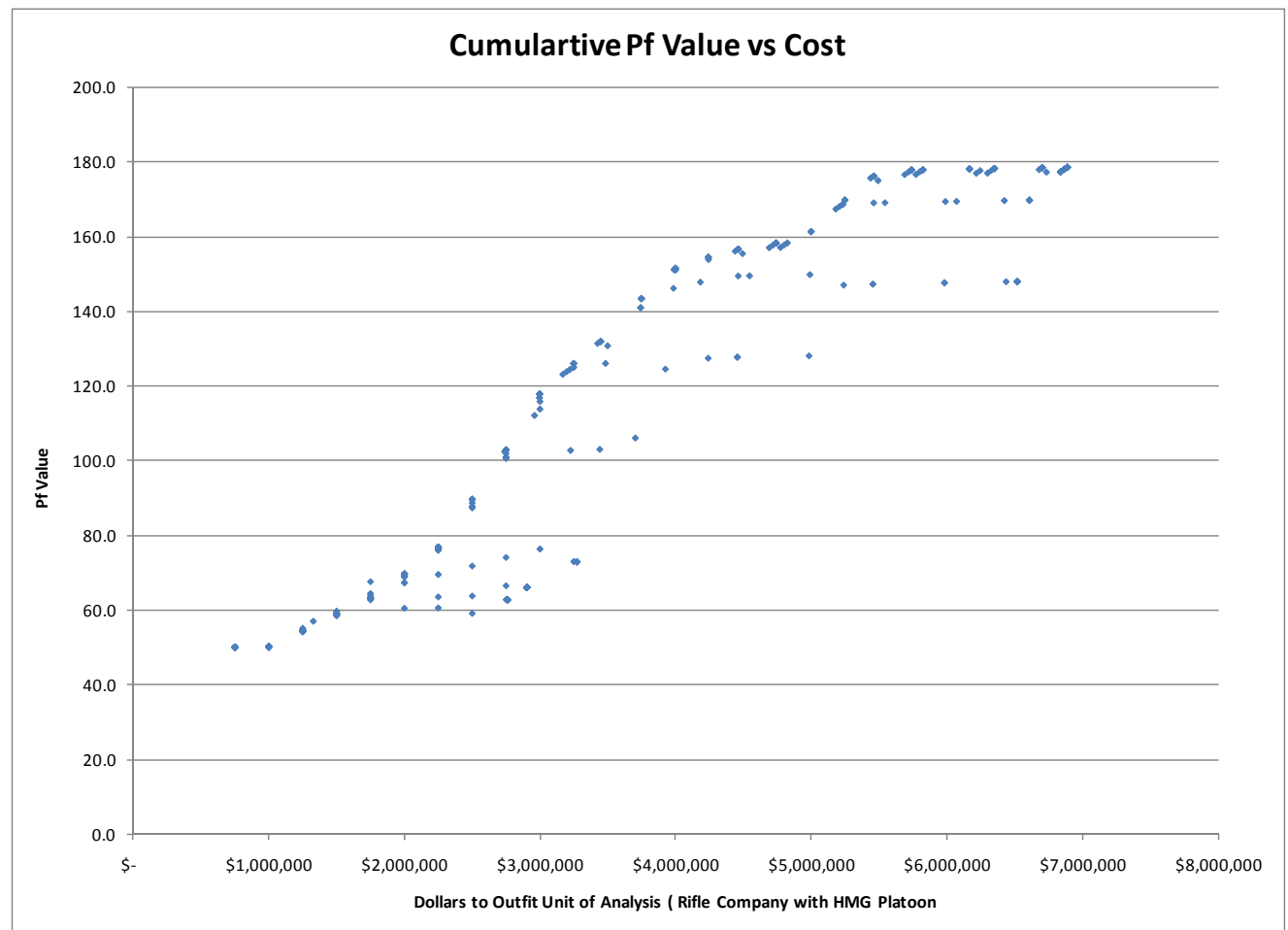 – Up to Four Objective Functions

▸ VBA Macro was used to

Optimization Runs

▸ Many calibration runs were conducted to refine the model structure and determine trade space.

▸ Optimization was run in a batch of 360 runs.
  – Cost for Unit of Analysis constrained was varied from $750k to $8m, but increments of $250k,
  – Number of unique systems to outfit unit of Analysis was varied from 16 to 25.

▸ Subsequent runs were conducted to determine the Pf that fullfilled all the capabilities at lowest cost.

▸ Current systems (Pf 2007) and Status Quo (Pf 2010, if not changes to procurement plan were made) were also added.

▸ Overall analysis looked at 363 separate Pfs.

▸ Model recorded Pf compositions, Value Score, Cost, Risk, Total Weight, Total Unique Systems and whether it passed all the constraints.

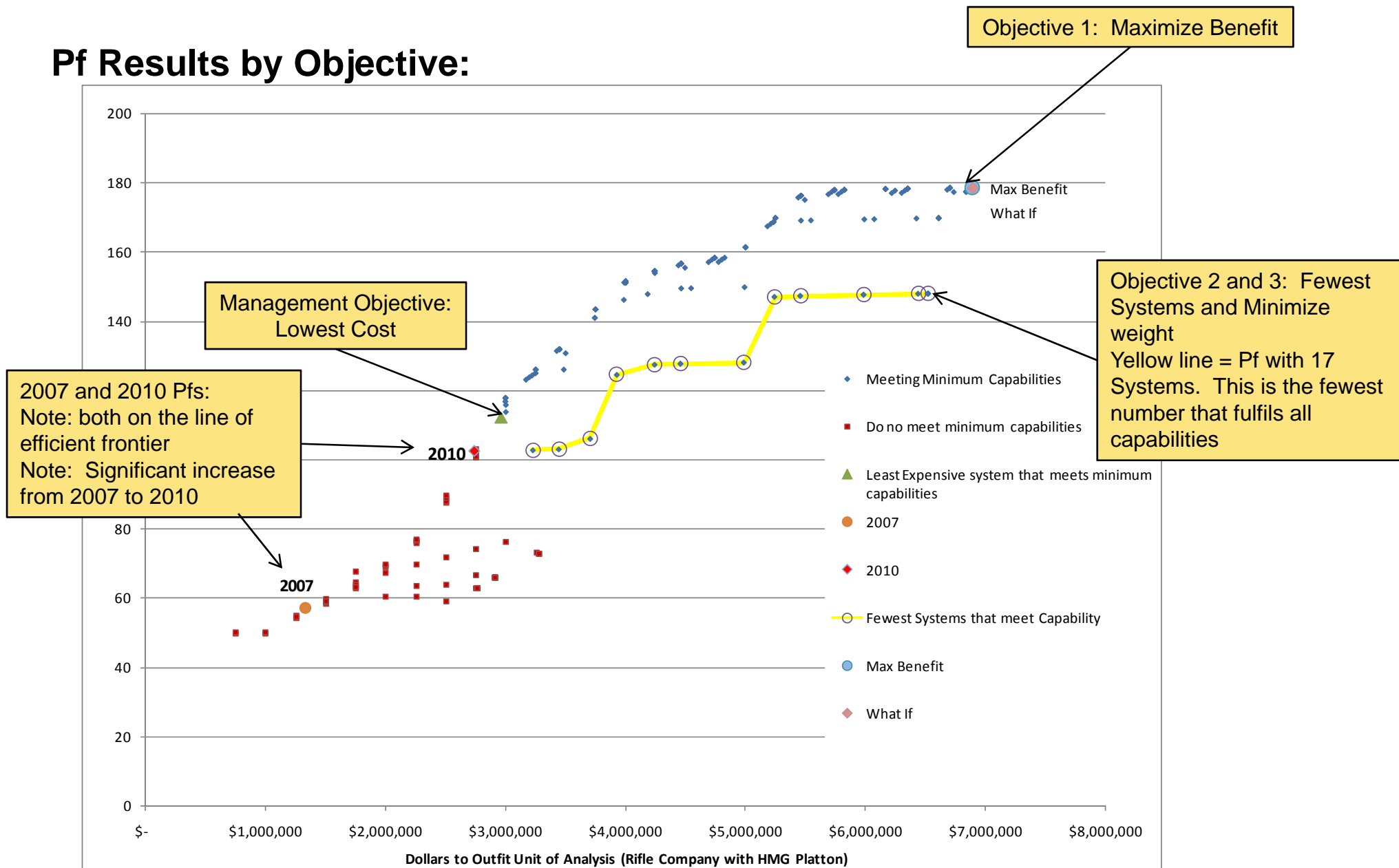# Optimization Output

▸ Initial output was messy to display and difficult to interpret.

▸ The data were stratified to lend some clarity.

Cumulartive Pf Value vs Cost

Pf Value (y-axis: 0.0 to 200.0)

Dollars to Outfit Unit of Analysis (Rifle Company with HMG Platoon (x-axis: $- to $8,000,000)

Pf Results by Objective:

Objective 1: Maximize Benefit

Management Objective: Lowest Cost

Objective 2 and 3: Fewest Systems and Minimize weight
Yellow line = Pf with 17 Systems. This is the fewest number that fulfils all capabilities

2007 and 2010 Pfs:
Note: both on the line of efficient frontier
Note: Significant increase from 2007 to 2010

Max Benefit
What If

2010

2007

- ◆ Meeting Minimum Capabilities
- ■ Do no meet minimum capabilities
- ▲ Least Expensive system that meets minimum capabilities
- ● 2007
- ◆ 2010
- ○ Fewest Systems that meet Capability
- ● Max Benefit
- ◆ What If

Dollars to Outfit Unit of Analysis (Rifle Company with HMG Platton)
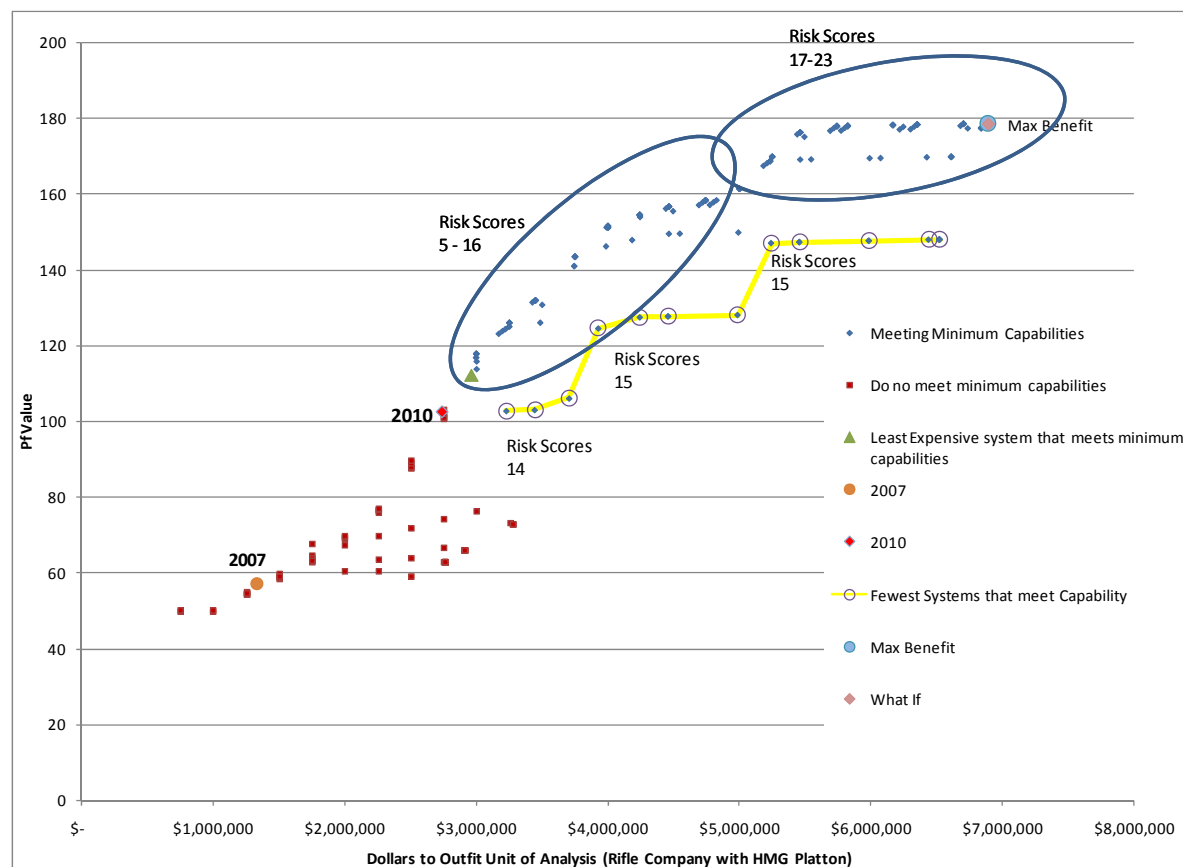
Risk Analysis

▸ As risk index was developed for each Pf. This number used a linear scale assigned to level of maturity. These numbers were summed within a Pf to gain a indication of relative risk. Risk was treated as a dependent variable, thus was never a binding constraint within the Pf optimization.

▸ In general, as Pf increased in effectiveness they was also an increased in risk, however within each circle there was not a linear relationship.

TRL	Risk Score
fielded	0
Requisitioned or 9	1
8	2
7	3
6	4
5	5
4	6
3	7
2	8
1	9

Chart labels: Risk Scores 17-23; Risk Scores 5 - 16; Risk Scores 15; Risk Scores 15; Risk Scores 14; Max Benefit; 2010; 2007

Legend:
- Meeting Minimum Capabilities
- Do no meet minimum capabilities
- Least Expensive system that meets minimum capabilities
- 2007
- 2010
- Fewest Systems that meet Capability
- Max Benefit
- What If

Y-axis: Pf Value
X-axis: Dollars to Outfit Unit of Analysis (Rifle Company with HMG Platton)

Sensitivity Analysis

▸ Two Types of Cost Sensitivity were complete

– Sensitivity with respect to technology maturity

– Sensitivity with respect to sunk cost

▸ Pf that are on the LOEF are sensitivity to either sunk cost or technology maturity depending on their placement on the curve.

▸ Pfs that achieve capabilities with fewer number of systems (right hand graph) are not sensitive to both technology maturity and sunk cost.

TRL	Percent Variation
4	20%
5	20%
6	20%
7	15%
8	10%
9	0%
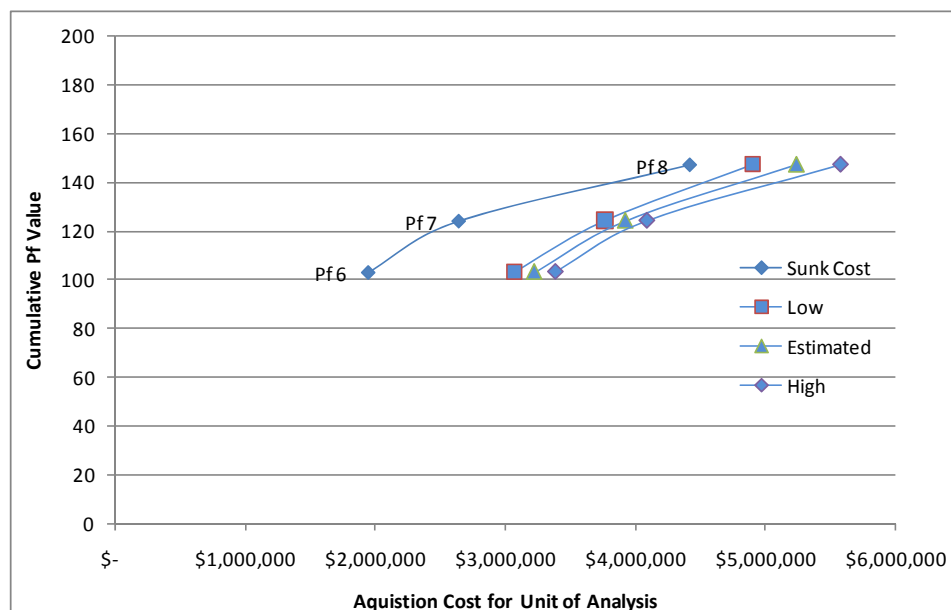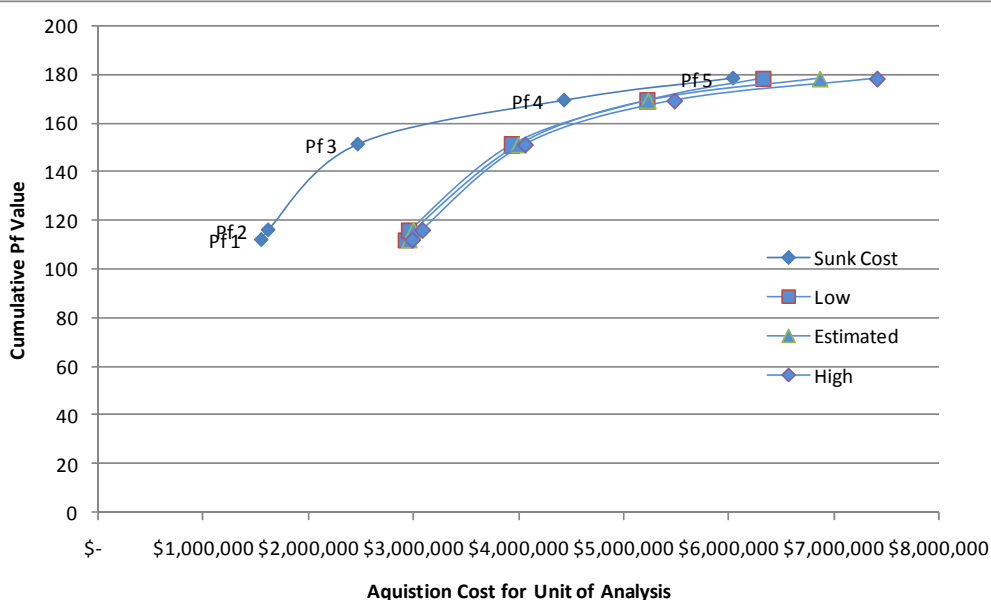
Lessons Learned and Areas of Further Study

▸ Process needed to be iterative

  – Draft results, take them all the way through, check, iterate.

  – Many calibration runs were conducted. First time through was always wrong.

▸ Pf Level Capabilities

  – System level objectives and capabilities were determined early

  – Pf level objectives were determined early, but not the capabilities

▸ Stakeholder involvement essential

  – PM, Tech, Cost, DA, operator; all brought something to the table

▸ Vary Pfs from the Points on Interest.

  – Further trades could be made from run of 363 Pfs

‣ Questions